Radio reflection tomography: Application to tomographic imaging of asteroids and comets

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We present the benefits and technical challenges of implementing a radio reflection tomography instrument to image the interiors of asteroids and comets. The rationale for imaging the interiors of these bodies includes both scientic and pratical arguments. The small bodies in our Solar System are of scientific interest because of the information they convey regarding the early conditions and processes which led to the solar system and planets. The interior structures provides information related to the manner in which these objects were built and evolved and to the conditions in the early solar system. Practical arguments for exploring the interiors of asteroids and comets are related to the potential for mining these bodies and for impact risk mitigation. Knowledge of the interior structure is required to determine the best strategies to use for impact risk mitigation.

We first describe the principles of the radio reflection tomographic technique and show how the collected data can be used to produce a volumetric image of the object. We then compare a radio reflection tomographic instrument design with the transmission radio tomography experiment CONSERT on the ROSETTA spacecraft. The CONSERT instrument is a bi-static radio transmission tomography instrument designed for exploring the interior of a comet. We show that the radio reflection tomography technique offers some important benefits over transmission tomography for exploring the interiors of asteroids and comets. Strengths of the reflection radio tomography instrument include: 1) a simpler and lower cost implementation since the technique is mono-static and does not require a lander; 2) a higher spatial resolution capability due to the inherent nature of the mono-static measurements which is sensitive to the high spatial frequency features of the object; and 3) the technique produces useful images of the interior even if complete penetration is not obtained. This is particularly important for asteroids whose interiors may be difficult to penetrate with a transmission experiment.

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